FG

12

AD

ADA034456

EDGEWOOD ARSENAL TECHNICAL REPORT

EB-TR-76082

AN ANATOMICAL INDEX IN BLUNT TRAUMA

by

William J. Sacco, Ph.D.
William P. Ashman, B.S.
Conrad L. Swann, B.B.A.

Biomedical Laboratory, Edgewood Arsenal

Howard R. Champion, F.R.C.S. (Ed.)
Mark Stega, B.S.
John Nolan, B.S.
William Gill, F.R.C.S. (Ed.)
R. A. Cowley, M.D.

Maryland Institute for Emergency Medicine
Baltimore, Maryland

December 1976

DEPARTMENT OF THE ARMY
Headquarters, Edgewood Arsenal
Aberdeen Proving Ground, Maryland 21010

Disclaimer

Disposition

UNCLASSIFIED

SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

REPORT DOCUMENTATION PAGE

READ INSTRUCTIONS BEFORE COMPLETING FORM

1. REPORT NUMBER: EB-TR-76082
2. GOVT ACCESSION NO.:
3. RECIPIENT'S CATALOG NUMBER:
4. TITLE (and Subtitle): AN ANATOMICAL INDEX IN BLUNT TRAUMA
5. TYPE OF REPORT & PERIOD COVERED: Technical Report, July 1975–February 1976
6. PERFORMING ORG. REPORT NUMBER:
7. AUTHOR(s):

W. J. Sacco, M. Stega, W. Gill, W. P. Ashman, J. Nolan, C. L. Swann, H. R. Champion, R. A. Cowley

8. CONTRACT OR GRANT NUMBER(s): AMSAA Contr DAA D0573C0032 (DAAD05-73-C-0032)
9. PERFORMING ORGANIZATION NAME AND ADDRESS: Commander, Edgewood Arsenal, Attn: SAREA-BL-BS, Aberdeen Proving Ground, Maryland 21010
10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS: Project 1T662617AH79
11. CONTROLLING OFFICE NAME AND ADDRESS: Commander, Edgewood Arsenal, Attn: SAREA-TS-R, Aberdeen Proving Ground, Maryland 21010
12. REPORT DATE: December 1976
13. NUMBER OF PAGES: 30 (29p.)
14. MONITORING AGENCY NAME & ADDRESS (if different from Controlling Office):
15. SECURITY CLASS. (of this report): UNCLASSIFIED
15a. DECLASSIFICATION/DOWNGRADING SCHEDULE: NA
16. DISTRIBUTION STATEMENT (of this Report)

Approved for public release; distribution unlimited.

Copies are available from: National Technical Information Service, Springfield, Virginia 22151.

17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report)

18. SUPPLEMENTARY NOTES

19. KEY WORDS (Continue on reverse side if necessary and identify by block number)

Anatomical index; Probability of survival; Diagnostic codes; Blunt trauma; Triage of patients

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

The case histories of 2,135 patients with acute blunt trauma, consecutively admitted to a hospital over a 48-month period, were studied in an attempt to produce an objective scale for the severity of injury. All injuries were coded using the Hospital Adaptation of International Classification of Disease (H-ICDA) prior to computer analysis. An "effective" probability of survival (P_E^1) for each injury code was tested for its ability to predict outcome on random subsets of patients. When used as an injury "score" the P_E^1 can predict survival rates to within ±6% with individual misclassification rates of 12%.

DD FORM 1 JAN 73 1473 EDITION OF 1 NOV 65 IS OBSOLETE

UNCLASSIFIED

SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

PREFACE

The work described in this report was authorized under AMSAA Contract DAA D0573C0032 and Project 1T662617AH79, Bioresponse to Trauma. This work was started in July 1975 and completed in February 1976.

Reproduction of this document in whole or in part is prohibited except with permission of the Commander, Edgewood Arsenal, Attn: SAREA-TS-R, Aberdeen Proving Ground, Maryland 21010; however, DDC and the National Technical Information Service are authorized to reproduce the document for United States Government purposes.

CONTENTS

AN ANATOMICAL INDEX IN BLUNT TRAUMA

I. INTRODUCTION.

In the Bioresponse to Trauma Research Program of the USA Armament Command, a new methodology is evolving for assessing wound severity from blunt and penetrating injuries. The rationale consists of characterizing injuries by strings of "diagnostic codes." The strings are correlated with mortality using similarly coded data on traumatic injuries from US Army and civilian data bases. A report documenting the methodology and its applications to the Bioresponse to Trauma Research Program is in preparation. This report discusses the development and validation of an anatomical index for multiple blunt trauma injuries.

The methodology has a wide range of potential military and civilian applications including validation of other injury assessment methods (such as the use of medical assessors), triage of patients, and evaluation of health care.

The present impetus to improve the management of trauma victims has provoked several attempts to develop a system for quantitating injury. The difficulties of characterizing a miscellany of injured patients are well recognized. Paradoxically, injury is more susceptible to quantitation than most disease processes because, despite potential complications, the inflicted injury is not progressive, and the anatomical disruption provides a static data base. The elements of anatomical quantitation which remain problematic include an agreement on definitions for labeling, assignment of a scoring system, and the synergistic effect of multiple injuries.

Factors which alter with time and influence the prognosis can be encompassed by the term "physiological response" to injury, initially described by Cuthbertson[1] but here used to include all metabolic and physiological responses to acute trauma. Such variables reflect not only the severity of the total trauma and the time elapsed since injury, but also the patient's age and pre- or co-existing diseases, both of which may affect the response to injury and the eventual outcome.

Existing quantitative systems have employed the degree of anatomical injury,[2-4] elements of the physiological and biochemical response,[5-7] and combinations of the two.[8,9] The anatomical approach usually involves the arbitrary assignment of numbers to a subjective evaluation of the severity of the injury. The Abbreviated Injury Scale (AIS)[4] is a ranking of injuries by their severity, and is used internationally by researchers, including multi-disciplinary accident investigation teams established by the United States Department of Transportation. The injury grades were based on an arbitrary scale developed by approximately 50 physicians, engineers, and researchers. No verification has established that a "3" assigned to urethral or pericardial contusion is truly equivalent to that "3" attached to a hemothorax, or that the number is meaningfully relative to the "5" of a tracheal avulsion. The methodology has been extended to include the additive effect of multiple injuries by using a quadratic equation which correlates with actual mortality figures.[10] The AIS has also been used to evaluate the Comprehensive Injury Scale[11] which includes estimates of energy dissipated, degree of impairment, and other factors not previously included in injury quantitation. In brief, the AIS is an alternative total assessment to that based on clinical judgment and derives from a consensual subjective assessment of anatomical injury on an arbitrary scale. It is a useful but limited tool when precise anatomical diagnosis is available either through surgery or postmortem examination.

Other attempts to quantify trauma have been specifically directed towards triage. The Trauma Index described by Kirkpatrick and Youmens[7] combines superficial anatomical assessment with some measure of physiological response in the form of pulse, blood pressure, cyanosis, and level of consciousness. Although the scoring system has not been validated, the index has been tested in Japan[12] and Pennsylvania[13] with a good correlation between the index rating and the clinical state of the injured patient 1 week later. The index appears to be of value in triage by paramedical personnel or in the emergency room, but lacks the precision required to compare management or to evaluate care.

This paper is an attempt to further the quest for an acceptable, practical system for quantitation of injury. The methodologies used were mathematically derived estimates of the probability of survival associated with injury to provide an objective assessment of the degree of trauma involved. An attempt was made to provide a system that could be easily applied to a widespread variety of needs including triage, comparison of therapeutic modalities, evaluation of health care, and validation of other indices.

II. METHODOLOGY.

All patients with acute trauma admitted to a single referral center over a 4-year period (1972-1975) were studied. Upon discharge or death, a detailed diagnosis was provided by the attending physician and coded according to the Hospital Adaptation of the International Classification for Disease Adapted for use in the United States (H-ICDA).[14] This coding was checked against diagnoses in the hospital chart in triplicate: by medical records personnel, by computer card punchers, and by medical students. When autopsy findings were available, any necessary alterations in coding were made. All analyses were performed on a Univac 1108 computer.

Initially, 2,833 patients were included in this study. Patients injured by weapons were excluded as were patients with injuries (lacerations, fractures, dislocations, various musculoskeletal injuries; intrathoracic, intraabdominal, intracranial, vascular, nerve, and spinal cord injuries) that were not within the H-ICDA code range of 800.0 to 959.0. After subtracting these exclusions, 2,135 patients were left for analysis. A random selection of 1,884 of these patients was used to establish the statistical methodology, and this group of patients was called the Training Set. Data on the remaining 251 patients (Test Set) were withheld to validate the methodology.

A. Methodology for the Training Set.

The training set of 1,884 patients provided a computed "conditional" probability of survival, P_C, and an "effective" probability of survival, P_E, for each injury code (in the range 800.0 to 959.9). The P_C was derived as the proportion of survivals associated with each injury code. The conditional probabilities were used to rank the severity of the injury codes by the decision rule that injury X was less severe than injury Y if the conditional probability of survival for injury X exceeded the conditional probability of survival for injury Y.

The ranking of injuries provided by P_C was then used to compute the P_E for each injury code. The P_E for a given injury code is the proportion of survivors in the subset of patients for whom this injury is the most severe injury sustained, the severity ranking being established by the P_C's.

B. Validation of the Methodology.

For each of five random subgroups of the training set and for the test set, the P_E for each code was used as a basis to validate the methodology. The probability of survival for each patient was estimated to be the P_E associated with the most severe injury. The P_E for each patient was used to compute the expected number of survivors for each subgroup of the training set and for the test set. The expected survival rate for a set of patients was computed by summing the probabilities of survival for all patients in that set. These values were compared with the actual number of survivors.

A decision rule predicting survival of a patient if the P_E associated with his most severe injury was greater than 0.5 was used as the basis for individual patient prediction. Misclassification rates (MR), based on this decision rule, were calculated from the formula

$$MR = P_S P_{FP} + P_D P_{FN}$$

where

P_S = a priori probability of survival

P_{FP} = probability of false positives = $\dfrac{\text{Number of patients predicted to die, but survived}}{\text{Number of survivors}}$

P_D = a priori probability of death = $1 - P_S$

P_{FN} = probability of false negatives = $\dfrac{\text{Number of patients predicted to live, but died}}{\text{Number of deaths}}$

This calculated misclassification rate was compared with an expected misclassification rate (EMR) derived from the formula

$$EMR = \sum_{R_1} p\,(L/Code)\; p\,(Code) + \sum_{R_2} (1 - p\,[L/Code]\; p\,(Code)$$

where

p (Code) = probability of the code appearing

R_1 = all codes for which p (L/Code) <0.5

R_2 = all codes for which p (L/Code) >0.5

p (L/Code) = probability of code appearing and patient surviving

C. Computation of Effective Probability of Survival Using the Entire Data Set.

Using the total set of 2,135 patients, the procedure was repeated. The P_C was computed for each injury code. These were used to rank the codes and to recompute a P_E for each code.

D. Computation of Effective Probability of Survival for Anatomical Groups of Codes.

The injury codes were grouped anatomically. An effective probability of survival was associated with each group (G). Each patient whose most severe injury was an injury code in G was assigned to a set (S_G). The P_E for G was computed to be the proportion of survivors in S_G. In this way, probabilities of survival were obtained for subclassifications of various anatomical groups.

E. Validation of Effective Probability of Survival.

The values for P_E, associated with each H-ICDA diagnostic code, were used to predict the survival rates of five random patient groups comprising the total study set. Individual deaths were predicted using the decision rule previously applied to validate the methodology, and misclassification rates were calculated.

III. RESULTS.

The 2,135 patients studied were assigned 259 different injury codes. There was at least one and up to 14 codes for each patient (table A-1, appendix A). A weighted regression line ($Y = 0.984 - 0.127X$) was computed for these data. Of the 2,135 patients, 1,751 (83%) survived.

Data from the training set of 1,884 random patients provided the probability calculations. The percentage of survivors in the training set was 82%. In this set – and for each of the 259 injury codes – the P_C, and subsequently the P_E were derived.

Of the 1,884 patients, 1,535 involved at least one of 40 diagnostic codes with a P_C less than 1.0 (i.e., the injury occurred at least once in a patient who died). The remaining 349 patients involved at least one of 117 codes which were never associated with fatalities. Conditional probabilities were used to rank the severity of the injury codes and to provide the basis for the computation of the P_E.

A. Effective Probability of Survival.

Of the 1,884 patients with computed effective probabilities of survival, 349 possessed one or more of 117 codes which were never associated with a patient death. Each of 1,171 patients was labelled with one of 72 injury codes which occurred as a highest ranked code. For each of these 72 injury codes, there was associated at least one death. Each of 364 patients had one of 61 codes which occurred as a highest ranked code; for patients experiencing these codes, there were no deaths. Seven codes existed which were associated with death although not in those patients where they occurred as the highest ranked code.

B. Test Set and Validation of Methodology.

The effective probabilities of death thus obtained for the training set were used on the 251 patients in the test set to predict the expected survival.

The survival rate predicted for the test set was 0.81. The survival rates predicted for the five random subsets of patients and the test set were consistently within 94% of the actual survival rate (table A-2). Misclassification rates for individual patients (including both false positives and false negatives) appear in table A-3.

C. Effective Probability on Whole Data Set.

The training set and test set patients combined provided a total population of 2,135 patients with acute blunt trauma. The P_C was used to rank and to compute the P_E associated with each diagnostic code. A summary of the data is shown in table A-4.

The results of the validation process for P_E are given in tables A-5 and A-6 with expected and actual survival rates and individual misclassification rates. The expected misclassification rate for the anatomical index was 0.12 and the actual rate experienced varied between 0.13 and 0.18 (table A-6). An example of the application of P_E for various anatomical groupings is shown in figure B, appendix B.

IV. DISCUSSION.

The P_C, associated with a given injury code, was computed as the proportion of survivors possessing a code. This reflects the survival associated with a given injury in the presence of any number of other injuries and, consequently, reflects both the severity of the individual injury and the frequency of its association with other injuries.

The P_C provides a statistical basis for the ranking of one injury against another in a manner which reflects their occurrence in the patient population studied. The P_C cannot be used as a severity score because certain incongruities occur where less severe injuries (such as a fractured humerus) are commonly associated with more severe injuries (such as a ruptured liver and cerebral contusion), resulting in an unreasonably high value for P_C. Application of the methodology to a larger data base from a variety of treatment centers, such as the Illinois Trauma Registry,[15] may result in precise ranking. Although infrequent, the effects of such incongruous values for P_C have predominantly been eliminated by the use of P_E as the "score."

The P_E was obtained by excluding (from the data set) all patients with injuries achieving a lower ranking probability of survival than the one under analysis. It is an attempt to estimate the impact of a specific injury in a real world setting, in that such injuries, when they do not occur alone, will have their maximum impact when they are the dominant injury.

Both P_C and P_E are objective values, unlike the arbitrary assignment forming the basis for the AIS and other current methods of quantitation. Internal consistency and statistical validity tests show that P_E can be used to predict expected survival rates in patient groups to within ±5% although the methodology is insufficiently developed to predict accurate individual outcomes. Attempts to predict the survival for an individual patient will often result in a misclassification. The range of the effective probabilities of survival for the injuries is 0.17 to

1.0. Thus, for a given injury with 60% chance of survival, prediction for an individual will result in misclassification 4 out of 10 times using our decision rule that predicts death if the probability of survival is less than 0.5. A 12% actual misclassification rate was found when the P_E from the training set was applied to the test set using a decision rule which predicts death if $P_E < 0.5$ and otherwise predicts survival. This compares favorably with the misclassification rates associated with existing decision rules and is the same as the expected misclassification rate. An empirical comparison with a random decision rule (RDR), based on the a priori probability of survival (p) for the patient population studied, is of some interest. The RDR predicts survival for a patient if a random number, r, chosen from a uniform distribution of numbers on the unit interval is less than or equal to p; if r is greater than p, the RDR predicts death. The expected survival rate associated with the RDR would be p, and the misclassification rate would be $2p(1 - p)$. This latter quantity is obtained as follows:

Misclassification rate = probability ($r \leq p$ and the patient dies) + probability ($r > p$ and the patient survives)

$$= p(1 - p) + (1 - p)p$$

$$= 2p(1 - p)$$

In our patient population $p = 0.82$ and $2p(1 - p) = 2(0.82)(0.18) = 0.30$.

The decision rule utilized in this study thus decreases the misclassification rate by 18% (30% to 12%) over a random prediction based on a knowledge of our patient population.

While the P_E value undoubtedly underestimates the probability of survival associated with isolated injury, it is a mean probability of survival for an individual injury associated with other less severe trauma and thus incorporates the interaction of multiple less severe injuries and the injury under scrutiny. Estimates for P_E within confidence limits of ±5% require samples of 60 to 1,000 patients per injury depending on the value of P_E. If applied to regional trauma registries, the P_E could form that valid objective basis for evaluation of care and achievement so long elusive to the medical profession.

Characterization of interactions which are present in multiple trauma is complex. Our data (table A-1) show surprisingly little overall effect in this context, while a separate study from the same center[16] and affirmed by Baker[10] showed a marked increase in the mortality rate when a severely damaged organ from another body system was added to a spectrum of injuries, but little effect from minor injuries Multiple injuries within one body system occur most frequently within the abdomen and musculoskeletal system. On the basis of relative frequency and severity, the additive effect of an intraabdominal or musculoskeletal injury will thus, in general, be less than that of a thoracic or central nervous system injury. A comprehensive model for multiple trauma should account for the most critical injury and the number and relative importance of the other injuries.

The results reported here might serve as a template on which a number of scales of injury could be formulated. Data on single injuries and injury combinations could eventually be computed with a high degree of confidence and with automatic updating. It is questionable whether such a degree of resolution, though intellectually appealing, would be of practical value and significantly improve the predictive capability reported here for a selected population.

The widely used H-ICDA is a code for recording injury and may form a realistic labeling basis for such a system of quantitation. In its present form, however, subjectivity enters the process of coding to some extent because the descriptive terminology lacks specificity and sensitivity for certain injuries. Minor modifications, and definitions to aid in the assignment of such labels as "moderate cerebral contusion," would ameliorate this problem.

The ability to make a definitive diagnosis in trauma depends on the training and skill of the diagnostician and on the facilities available to aid in the diagnosis. Thus, a paramedic may discern that a patient has a chest injury; a physician may suspect a hemothorax; but the diagnosis is only confirmed by aspiration of blood and clearing of the effusion seen on chest X-ray. By combining the diagnostic groups as in figure B, we are introducing a refinement of the statistical methodology which, when combined with a single parameter of physiological response (e.g., respiratory rate or level of consciousness), may be of benefit in triage or may add refinement to scoring systems already existing for this purpose.

The P_E offers a mathematically derived data-based scale for measuring the effect of injury on the basis of anatomical disruption to individual organs or groups of organs. It has been derived from and tested on a select limited patient population. The statistical methodology has been validated. The methodology has a wide range of potential applications from validation of other injury-scoring systems to evaluation of health care delivery. It offers a system of scoring based on a specific diagnosis of the most severe injury as opposed to one based on an arbitrary assignment to a group of presumed equivalent injuries.

Baker *et al.*[10] added a new dimension to quantitation by correlating the arbitrary severity scores of the AIS with mortality. By utilizing the H-ICDA coding system, our methodology can easily be integrated into the medical records system of a hospital. A prospective comparison with the AIS would be another tentative step towards widespread systematic measurement of injury and treatment.

LITERATURE CITED

1. Cuthbertson, D. P. The Disturbance of Metabolism Produced by Bony and Non-Bony Injury, with Notes on Certain Abnormal Conditions of Bone. Biochem. J. *24*, 1244 (1930).

2. Ryan, G. A., and Garrett, J. W. A Quantitative Scale of Impact Injury. CAL. No. VT-1823-R34, Buffalo Cornell Aeronautical Laboratory, Inc., Cornell University, Buffalo, New York. 1968.

3. Andreassen, M., Donde, R., Herman, F., Hermann, K., Rasmussen, K., Riishede, J., Schmidt, A., and Sorenson, C. Index of Severity of Accidents: An Attempt at Definition. Dan. Med. Bull. *19*, 51-54 (1972).

4. Joint Committee on Injury Scaling: The Abbreviated Injury Scale, 1975 Revision. Proc. 19th Conf. Am. Assoc. for Automot. Med., Lake Bluff, Illinois, Am. Assoc. for Automot. Med., 1975.

5. Allgower, M., and Burri, C. Schockindex. Dtsch. Med. Wochenschr. *92*, 1947, 1967.

6. Weil, M. H., and Afifi, A. A. Experimental and Clinical Studies on Lactate and Pyruvate as Indicators of the Severity of Acute Circulatory Failure (Shock). Circulation *41*, 989-1001 (1970).

7. Cowley, R. A., Sacco, W. J., Gill, W., Champion, H. R., Long, W. B., Copes, W. S., Goldfarb, M. A., and Sperrazza, J. A Prognostic Index for Severe Trauma. J. Trauma *14*, 1029-1035 (1974).

8. Kirkpatrick, J. R., and Youman, R. L. Trauma Index: An Aid in the Evaluation of Injury Victims. J. Trauma *11*, 711-714 (1974).

9. Williams, R. E., and Schamadan, J. L. The SIMBOL Rating and Evaluation System. A Measurement Tool for Injured Persons. Ariz. Med. *26*, 886-887 (1964).

10. Baker, S. P., O'Neill, B., and Haddon, W. Injury Severity Score: A Method for Describing Patients with Multiple Injuries and Evaluating Emergency Care. J. Trauma *14*, 187-196 (1974).

11. Committee on Medical Aspects of Automotive Safety: Rating the Severity of Tissue Damage II, the Comprehensive Scale. J. Am. Med. Assoc. *220*, 717-720 (1972).

12. Ogawa, M., and Sugimoto, T. Rating Severity of the Injured by Ambulance Attendants. J. Trauma *14*, 934-937 (1974).

13. Demuth, W. E. Trauma Index – Evaluating Injury Victims. Pa. Med. *77*, 56-57 (1974).

14. Hospital Adaptation of International Classification of Disease Adapted. 2nd Edition. Commission on Professional and Hospital Activities, Ann Arbor, Michigan, 1973.

15. Boyd, D. R., Lowe, R. J., Baker, R. J., and Nyhvs, L. M. Trauma Registry – New Computer Method for Multifactoral Evaluation of a Major Health Problem. J. Am. Med. Assoc. *223*, 422-428 (1973).

16. Gill, W., Champion, H. R., Long, W. B., Stega, M., Nolan, J., Decker, R., Misjinsky, M., and Cowley, R. A. A Clinical Experience in Major Multiple Trauma in Maryland. Md. State Med. J. *1*, 55-58 (1976).

APPENDIX A

TABLES

Table A-1. Distribution of Injury and Attendant Survival in Population Studied

No. of codes	No. of patients	Percent of total patients	No. of diagnostic codes	Probability of survival
1	512	24.0	512	0.86
2	476	22.3	952	0.84
3	372	17.4	1,116	0.82
4	285	13.3	1,140	0.81
5	194	9.1	970	0.79
6	115	5.4	690	0.77
7	73	3.4	511	0.76
8	55	2.6	440	0.75
9	27	1.3	243	0.72
10	13	0.6	130	0.71
11	8	0.4	88	0.69
12	3	0.1	36	
14	2	0.1	28	
Total	2,135	100.0	6,856	

NOTE: Mean injuries per patient: 3.2

Table 2. Predicted Death Rates in Five Random Subsets of Training Set Patients and a Test Set of 251 Patients using P_E from Training Set

	No. of patients	Lived	Died	No. of predicted deaths	Percent accuracy
Training set	422	346	76	79	99.3
	429	350	79	79	100.0
	442	351	91	89	99.6
	423	350	73	87	96.7
	168	138	30	33	98.3
Total (training)	1,884	1,535	349	367	99.1
Total (test)	251	217	34	47	94.8
Total study set	2,135	1,752	383	414	98.5

Table 3. Misclassification Rates in Five Random Subsets of Training Set Patients and a Test Set of 251 Patients Using P_E from Training Set

	No. of patients	Lived	Died	No. of misclassifications	Number predicted to die but lived	Number predicted to live but died	Misclassification rate
Training set	422	346	76	64	20	44	0.15
	429	350	79	76	17	59	0.18
	442	351	91	79	8	71	0.18
	423	350	73	62	10	52	0.15
	168	138	30	30	8	22	0.18
Total (training)	1,884	1,535	349	311	63	248	0.17
Total (test)	251	217	34	30	6	24	0.12
Total study set	2,135	1,752	383	341	69	272	

Table A-4. Effective Probability of Survival (P_E) for the Various H-ICDA Codes

H-ICDA code	Diagnosis		Conditional probability of survival		Effective probability of survival	
			Size	P_C	Size	P_E
800.0	Fractured vault of skull (closed)		69	0.72	30	0.87
800.1	Fractured vault of skull (open)		24	0.62	11	0.82
801.0	Fractured base of skull (closed)		119	0.68	75	0.81
801.1	Fractured base of skull (open)		16	0.62	9	0.78
802.0	Fractured nasal bones (closed)		45	0.87	10	1.00
802.1	Fractured nasal bones (open)		8	0.88	3	1.00
802.2	Fractured mandible (closed)		90	0.82	23	1.00
802.3	Fractured mandible (open)		25	0.92	1	1.00
802.4	Other facial fractures (closed)		138	0.83	23	1.00
802.5	Other facial fractures (open)		11	0.82	2	1.00
805.0	Fractured cervical spine (closed)	Without cord lesion	59	0.76	39	0.90
805.1	Fractured cervical spine (open)	Without cord lesion	1	0	1	0
805.2	Fractured thoracic spine (closed)	Without cord lesion	24	0.96	5	1.00
805.3	Fractured thoracic spine (open)	Without cord lesion	2	1.00	2	1.00
805.4	Fractured lumbar spine (closed)	Without cord lesion	26	0.96	6	1.00
806.0	Fractured cervical spine (closed)	With cord lesion	22	0.77	14	0.79
806.2	Fractured thoracic spine (closed)	With cord lesion	12	1.00	12	1.00
806.4	Fractured lumbar spine (closed)	With cord lesion	9	0.89	1	1.00
806.6	Fractured sacrum and coccyx (closed)	With cord lesion	3	1.00	3	1.00
807.0	Fractured ribs (closed)		240	0.77	41	0.98
807.2	Fractured sternum (closed)		15	0.80	3	1.00
807.6	Flail chest		21	0.67	13	0.70
808.0	Fractured pelvis (closed)		180	0.82	30	0.93
808.1	Fractured pelvis (open)		6	0.67	3	0.67
810.0	Fractured clavicle (closed)		75	0.83	12	1.00
810.1	Fractured clavicle (open)		5	0.80	1	1.00
811.0	Fractured scapula (closed)		32	0.88	2	1.00
812.0	Fractured upper end of humerus (closed)		22	0.96	2	1.00
812.2	Fractured shaft humerus (closed)		49	0.57	45	1.00
812.3	Fractured shaft humerus (open)		16	0.69	11	1.00
812.4	Fractured lower humerus (closed)		27	0.85	3	1.00
813.0	Fractured upper radius and ulna (closed)		58	0.79	16	1.00
813.1	Fractured upper radius and ulna (open)		21	0.86	2	1.00
813.2	Fractured shaft radius and ulna (closed)		20	0.85	2	1.00
813.3	Fractured shaft radius and ulna (open)		3	1.00	2	1.00
813.4	Fractured lower radius and ulna (closed)		47	0.96	3	1.00
813.5	Fractured lower radius and ulna (open)		9	1.00	1	1.00

Table A-4. (Contd)

H-ICDA code	Diagnosis	Conditional probability of survival		Effective probability of survival	
		Size	P_C	Size	P_E
814.0/814.1	Fractured carpal bones	17	0.82	3	1.00
815.0	Fractured metacarpal bones	21	0.90	5	1.00
820.0	Fractured neck of femur (closed)	19	0.68	9	1.00
820.1	Fractured neck of femur (open)	5	1.00	5	1.00
820.2	Fractured trochanteric section (closed)	7	0.86	1	1.00
820.3	Fractured trochanteric section (open)	2	1.00	2	1.00
820.4	Fractured femur (closed)	18	0.78	6	1.00
820.5	Fractured femur (open)	7	1.00	6	1.00
821.0	Fractured shaft (closed)	165	0.69	47	0.98
821.1	Fractured shaft (open)	48	0.83	8	1.00
821.2	Fractured lower end femur (closed)	27	0.89	0	N/A
821.3	Fractured lower end femur (open)	14	0.79	6	1.00
822.0	Fractured patella (closed)	26	0.96	0	N/A
822.1	Fractured patella (open)	19	0.79	8	1.00
823.0	Fractured upper tibia and fibula (closed)	116	0.68	56	0.99
823.1	Fractured upper tibia and fibula (open)	97	0.82	34	0.97
823.2	Fractured shaft tibia and fibula (closed)	20	0.90	3	1.00
823.3	Fractured shaft tibia and fibula (open)	26	0.92	2	1.00
824.0	Fractured ankle (closed)	72	0.85	15	1.00
824.1	Fractured ankle (open)	26	0.92	5	1.00
825.0	Fractured tarsal or metatarsal (closed)	33	0.91	1	1.00
825.1	Fractured tarsal or metatarsal (open)	11	1.00	11	1.00
826.0	Fractured phalanges foot (closed)	8	1.00	8	1.00
826.1	Fractured phalanges foot (open)	2	1.00	2	1.00
831.0	Dislocation of shoulder	16	0.91	4	1.00
832.0	Dislocation of elbow	5	1.00	5	1.00
833.0	Dislocation of wrist	5	1.00	5	1.00
835.0	Dislocation of hip	36	0.92	1	1.00
836.0	Dislocation of knee	9	0.67	7	0.86
837.0	Dislocation of ankle	4	1.00	4	1.00
838.0	Dislocation of foot	2	1.00	2	1.00
850.0	Concussion	217	0.97	42	0.98

Table A-4. (Contd)

H-ICDA code	Diagnosis	Conditional probability of survival		Effective probability of survival	
		Size	P_C	Size	P_E
851.0	Cerebral contusion (closed)	157	0.75	60	0.95
851.1	Cerebral contusion (open)	16	0.44	9	0.33
851.2	Cerebral contusion (mild)	204	0.77	28	0.86
851.3	Cerebral contusion (moderate)	120	0.31	47	0.33
851.4	Cerebral contusion (severe)	63	0.18	23	0.17
851.5	Cerebral laceration	1	0	1	0
851.6	Brain stem contusion	44	0.48	35	0.52
851.7	Cerebellar contusion	1	1.00	1	1.00
851.8	Brain stem or cerebellar laceration	2	0	2	0
852.0	Intercranial hemorrhage	30	0.47	29	0.48
852.2	Extradural hemorrhage	3	0.67	3	0.67
852.3	Subdural (acute hemorrhage)	9	0.56	9	0.56
852.6	Subarachnoid hemorrhage)	2	0.50	2	0.50
853.0	Other intercranial hemorrhage	9	0.44	5	0.60
853.2	Cerebral hemorrhage	3	0.67	0	N/A
854.1	Unspecified head injury	44	0.30	43	0.30
860.0	Pneumohemothorax	274	0.69	108	0.82
861.0	Myocardial contusion	18	0.56	18	0.56
861.2	Lung contusion or laceration	98	0.77	10	0.90
862.0	Ruptured aorta, bronchus, esophagus	103	0.57	84	0.63
863.0	Injury to G-I tract	166	0.77	16	0.75
864.0	Closed liver injury	233	0.65	161	0.70
865.0	Closed splenic injury	239	0.69	69	0.90
866.0	Closed kidney injury	24	0.62	20	0.75
867.0	Closed injury to pelvic organs	38	0.56	31	0.58
868.0	Other intraabdominal injuries	256	0.69	63	0.83
870.0	Eye injury	66	0.96	8	0.88
870.1	Complicated eye injury	6	0.83	1	1.00
872.0	Ear injury	33	0.94	6	1.00
873.0	Scalp lacerations	188	0.88	62	0.99
873.2	Nasal laceration	18	1.00	18	1.00
873.7	Facial lacerations	494	0.90	96	0.99
874.0	Neck lacerations	35	0.83	17	1.00
874.1	Complicated neck lacerations	16	0.81	10	0.94

Table A-4. (Contd)

H-ICDA code	Diagnosis	Conditional probability of survival		Effective probability of survival	
		Size	P_C	Size	P_E
875.0	Chest wall laceration	26	0.92	8	1.00
875.1	Complicated chest wall lacerations	11	0.90	6	1.00
876.0	Lacerations of back	8	0.88	3	1.00
879.0	Lacerations of trunk	30	0.90	12	1.00
879.1	Complicated lacerations of trunk	8	0.75	7	1.00
879.7	Multiple lacerations	51	0.80	13	0.92
880.0	Laceration of shoulder and upper arm	37	0.95	7	1.00
880.1	Complicated lacerations of shoulder and arm	5	1.00	5	1.00
881.0	Laceration of elbow, forearm, and wrist	33	0.94	3	1.00
881.1	Complicated laceration of elbow, forearm, and wrist	5	1.00	5	1.00
882.0	Laceration of hand	29	0.90	13	1.00
883.0	Laceration of fingers	12	0.82	2	1.00
884.0	Multiple and unspecified lacerations of upper limb	24	0.96	3	1.00
886.0	Traumatic amputation of fingers	4	1.00	4	1.00
887.0	Traumatic amputation of arm	8	0.75	3	1.00
890.0	Laceration of hip and thigh	33	0.91	6	1.00
890.1	Complicated laceration of hip and thigh	15	0.93	8	1.00
891.0	Laceration of lower leg	132	0.92	15	1.00
891.1	Complicated laceration of lower leg	8	1.00	8	1.00
892.0	Laceration of foot	15	0.87	4	1.00
894.0	Multiple lacerations of lower limb	5	0.80	2	1.00
896.0	Traumatic amputation of foot	4	0.75	2	1.00
897.0	Traumatic amputation of leg	12	0.83	4	1.00
958.0	Cervical spinal cord lesion with no evidence of vertebral injury	15	0.73	10	0.90
958.4	Lumbar spinal cord lesion with no evidence of vertebral injury	3	1.00	3	1.00

Table A-5. Predicted Death Rates in Subsets of Total Patient Population Using P_E from the Total Patient Population

No. of patients	Lived	Died	No. of predicted deaths	Percent accuracy
422	346	76	76	99.3
429	350	79	77	99.5
442	351	91	86	98.8
423	350	73	85	97.2
419	355	64	79	96.4
Total 2,135	1,752	383	403	99.0

Table A-6. Misclassification Rates in Subsets of Total Patient Population Using P_E from the Total Patient Population

	No. of patients	Lived	Died	No. of misclassifications	Number predicted to die but lived	Number predicted to live but died	Misclassification rates
	422	346	76	66	19	47	0.16
	429	350	79	76	16	60	0.18
	442	351	91	78	5	73	0.18
	423	350	73	63	7	56	0.15
	419	355	64	53	6	47	0.13
Total	2,135	1,752	383	336	53	283	Avg 0.16

APPENDIX B

FIGURE

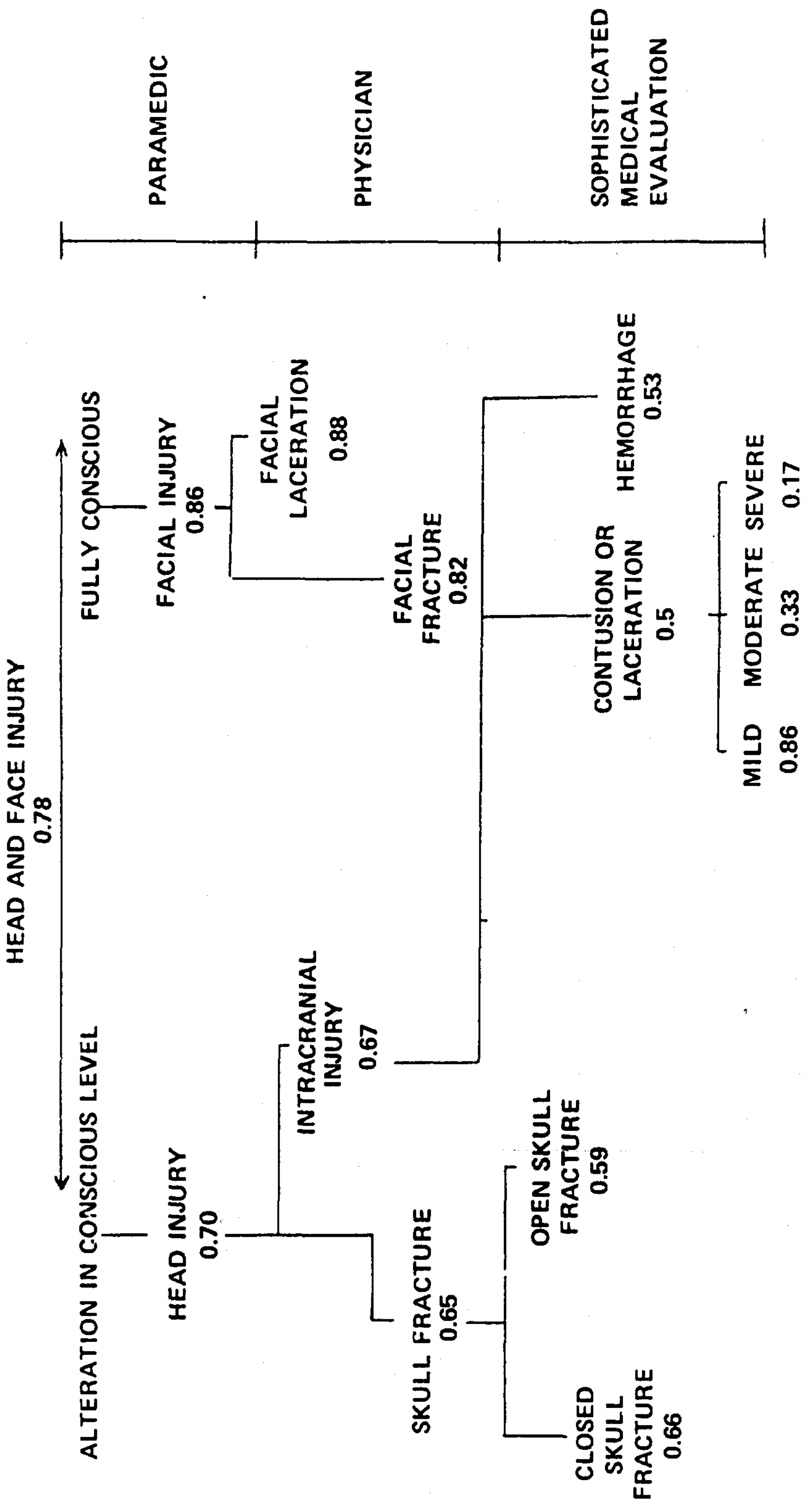

Figure B. Example of Groupings of Diagnostic Codes Related to Head and Face Injury with Attendant Probability of Survival (P_E) for Use at Varying Levels of Triage

DISTRIBUTION LIST FOR TR 76082

Names	Copies
EDGEWOOD ARSENAL	
TECHNICAL DIRECTOR	
Attn: SAREA-TD-E	1
FOREIGN INTELLIGENCE OFFICER	1
CHIEF, DEMILITARIZATION/DISPOSAL OFFICE	
Attn: SAREA-DM-E/Dr. Ward	1
CHIEF, LEGAL OFFICE	1
CHIEF, SAFETY OFFICE	1
CDR, US ARMY TECHNICAL ESCORT CENTER	1
PUBLIC HEALTH SERVICE LO	1
AUTHOR'S COPY, Biomedical Laboratory	7
BIOMEDICAL LABORATORY	
Attn: SAREA-BL-M	1
Attn: SAREA-BL-V	1
CHEMICAL LABORATORY	
Attn: SAREA-CL-B	1
Attn: SAREA-CL-BS	1
Attn: SAREA-CL-P	1
DIRECTOR OF PRODUCT ASSURANCE	
Attn: SAREA-PA-A	1
Attn: SAREA-PA-Q	1
DIRECTOR OF TECHNICAL SUPPORT	
Attn: SAREA-TS-R	2
Attn: SAREA-TS-L	3
Attn: SAREA-TS-E	1
DEPARTMENT OF DEFENSE	
Administrator Defense Documentation Center Attn: Accessions Division Cameron Station Alexandria, VA 22314	12
Director Defense Intelligence Agency Attn: DB-4G1 Washington, DC 20301	1
DEPARTMENT OF THE ARMY	
HQDA (DAMO-SSC) WASH DC 20310	1
Director Defense Civil Preparedness Agency	
Attn: RE	1
Attn: PO(DC)	1
Washington, DC 20301	

Names	Copies
OFFICE OF THE SURGEON GENERAL	
Commander US Army Research Institute of Environmental Medicine Attn: SGRD-UE-CA Natick, MA 01760	1
US ARMY HEALTH SERVICE COMMAND	
Superintendent Academy of Health Sciences US Army	
Attn: HSA-CDC	1
Attn: HSA-IHE	1
Fort Sam Houston, TX 78234	
US ARMY MATERIEL DEVELOPMENT AND READINESS COMMAND	
Commander US Army Materiel Development and Readiness Command	
Attn: DRCDE-DM	1
Attn: DRCLDC	1
Attn: DRCMT	1
Attn: DRCSF-S	1
5001 Eisenhower Ave Alexandria, VA 22333	
Commander DARCOM, STITEUR Attn: DRXST-ST1 Box 48, APO New York 09710	1
Commander US Army Science & Technology Center-Far East Office APO San Francisco 96328	1
Project Manager for Chemical Demilitarization and Installation Restoration Attn: DRCPM-DR, Bldg E4585 APG-Edgewood Area	1
Redstone Scientific Information Center Attn: Chief, Documents US Army Missile Command Redstone Arsenal, AL 35809	1
US ARMY ARMAMENT COMMAND	
Commander US Army Armament Command	
Attn: DRSAR-ASN	1
Attn: DRSAR-RDT	1
Rock Island, IL 61201	

Names	Copies
Commander Rocky Mountain Arsenal Attn: SARRM-EA Attn: SARRM-MD Denver, CO 80240	 1 1
Commander Frankford Arsenal Attn: Library Branch, TSP-L Bldg 51-2 Philadelphia, PA 19137	 1
US ARMY TRAINING & DOCTRINE COMMAND	
Commandant US Army Infantry School Combat Support & Maintenance Dept. Attn: NBC Division Fort Benning, GA 31905	 1
Commander US Army Infantry Center Attn: ATZB-CD-MS-C Fort Benning, GA 31905	 1
US ARMY TEST & EVALUATION COMMAND	
Record Copy CDR, APG Attn: STEAP-AD-R/RHA APG-Edgewood Area, Bldg E5179	 1
CDR, APG Attn: STEAP-TL APG-Aberdeen Area	 1
US MARINE CORPS	
Director, Development Center Marine Corps Development & Education Command Attn: Ground Operations Division Quantico, VA 22134	 1
DEPARTMENT OF THE AIR FORCE	
HQ Foreign Technology Division (AFSC) Attn: PDRR Wright-Patterson AFB, OH 45433	 1
Director Air Force Inspection and Safety Center Attn: IGD(AFISC/SEV) Norton AFB, CA 92409	 1
Commander Armament Development & Test Center Attn: DLOSL (Technical Library) Eglin AFB, FL 32542	 1
NORAD Combat Operations Center/DBN Cheyenne Mtn Complex, CO 80914	1
OUTSIDE AGENCIES	
Battelle, Columbus Laboratories Attn: TACTEC 505 King Avenue Columbus, OH 43201	 1